MARINE GEOLOGY

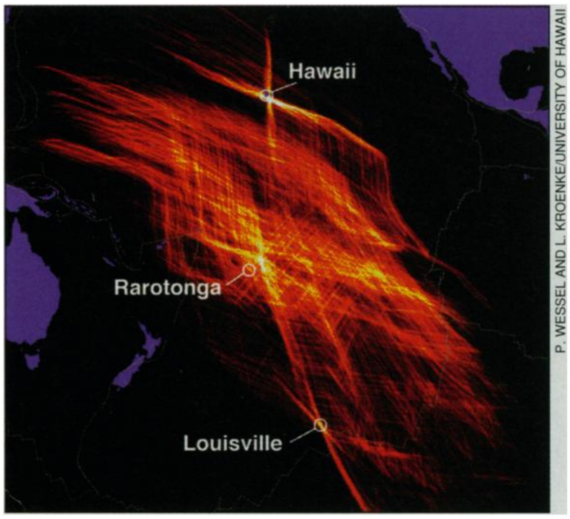
New Way to Hit the Hot Spot Hints at a Complex Pacific

Hundreds of volcanoes, some active like Hawaii, others long dead like Samoa and Bikini, poke above the blue waters of the wide Pacific. But these islands don't begin to suggest the profusion of more than 10,000 submerged volcanic seamounts now known to dot the Pacific sea floor. Many marine geologists have argued that these are the products of a dozen or so "hot spots," fixed sites of deep-seated volcanism that left a trail of seamounts as the oceanic plate moved over them. But these hot spots are often elusive, smoldering unnoticed beneath the sea floor or burned out long ago. Now two marine geophysicists have come up with an elegant way to track them down.

Geophysicists already have a search technique, but it requires knowing seamount ages, which can be hard to come by. In this week's issue of *Nature*, marine geophysicists Paul Wessel and Loren Kroenke of the University of Hawaii describe their new method, which relies on simple geometry yet seems to pinpoint some hot spots more precisely than before. In fact, these first results raise questions about traditional hot-spot theory, hinting that the volcanism responsible for many of the Pacific seamounts may not be as deeply rooted in the mantle or as stationary as researchers had thought. "It's a really elegant method, very clever," says marine geophysicist Seth Stein of Northwestern University. "It's a more objective way of testing a lot of things."

In the traditional "backtracking" method, the volcanic track burned through the sea floor guides researchers to the hot spot. For instance, the Hawaiian Islands and the Emperor Seamounts stretch across the North Pacific in a broad V with the point toward the southwest; the bend in this chain formed 43 million years ago when the Pacific Plate abruptly shifted direction. By radiometrically dating rocks from at least a few seamounts and knowing the plate's motion from the shape of the seamount track, researchers can backtrack along the chain to where the hot spot should be—beneath the island of Hawaii, in the world's clearest example. But in other cases, it is hard to fathom just how an assortment of poorly dated seamounts might sort into a series of hot-spot tracks, especially if the hot spots themselves have gone dormant and no longer spark the telltale volcanism. In one small region of the Pacific, around the Line Islands, researchers have proposed up to five separate hot spots to explain the chaotic jumble of seamounts.

Wessel was using this backtracking approach in a study of Pacific volcanism when something went awry. "I was trying to write the backtrack code [on my computer]," he says, "but the first time I did, I made a mistake." Instead of producing Hawaii's familiar V-shaped hot-spot track with the bend pointing to the southwest, the computer produced a mirror image, with the bend pointing to the northeast. Wessel realized that the computer had traced not the chain of seamounts seen today but the actual path of a single seamount over time, as plate motions dragged it away from the hot spot first in one direction and then another.



X marks the spot? A new method pinpoints a few Pacific hot spots but raises questions about the reality of others.

When Wessel plotted these "sea-floor flow lines" for several seamounts in the Hawaii-Emperor chain, he noticed that they formed two trends, tracking seamount paths before and after the shift in direction. The trends cross to form an X marking the one position every seamount had passed across: the site of the hot spot. This technique, Wessel realized, freed him from the need to know seamount ages. Hence, rather than being limited to a couple of hundred seamounts that were often poorly dated, he could instead seek hot spots for any seamounts whose positions were mapped. And thanks to a recent burst of declassification of military-satellite data—which reveal the tiny sea-surface bulges induced by seamounts' gravity (*Science*, 3 March 1995, p. 1260)—information was available on 8800 Pacific seamounts taller than 1 kilometer.

With this new technique in hand, Wessel and Kroenke set out in search of Pacific hot spots. In Hawaii, hot spotting initially came up with a big bright X 150 kilometers from current volcanic activity. So Wessel and Kroenke inserted a slight change in plate direction 3 million years ago—an adjustment other researchers had earlier suggested for independent reasons—and Hawaii appeared right on target. But the X marking another well-known feature in the far southern South Pacific, the Louisville hot spot, still fell 375 kilometers from its traditional location. In this case, however, it seems that the conventional methods are off and hot spotting is on the money. Seismic rumblings have been detected within 75 kilometers of the X, and last year, dredging at the site of seismic activity uncovered fresh lava within 100 meters of the surface, suggesting an active volcano. Hot spotting also puts a big X near, although not right on, the traditional site of the Rarotonga hot spot (see illustration).

In this preliminary analysis, however, no obvious X's appeared to mark the rest of the dozen or so other presumed Pacific hot spots. "I would have expected that there would be more very bright spots," says paleomagnetician Gary Acton of Texas A&M University. Instead, "there were a lot of fuzzy regions." Wessel and Kroenke say that problems such as inaccurate assumed plate motions could explain the fuzzy patches.

On the other hand, the problem may not be in the data but in traditional hot-spot theory, say Wessel and Kroenke. The idea has been that hot-spot volcanoes are fed by deep, hot plumes reaching to the very bottom of the mantle near Earth's core. Such deeply rooted hot spots should not move much, and indeed the Hawaii and Louisville hot spots have not moved detectably relative to each other, according to hot-spotting results. But hot spots that are drifting relative to each other because they have shallow or no roots could create the fuzzy pattern.

The hot-spotting results are "pointing up the real problems we have with plume theory," says geophysicist Marcia McNutt of the Massachusetts Institute of Technology. Her fieldwork and that of others has suggested that some sea-floor volcanoes might form a chain not one at a time but all at once, as magma that had pooled just below a plate leaked up along a crack or weak zone. Still, the answers are not yet clear. Even Wessel agrees that "things aren't suddenly easy now that we have this technique." However, with this new method, he says, the hunt for hot-spot origins is likely to heat up.

–Richard A. Kerr